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PATENT SPECIFICATION

(11) 1 215 864

DRAWINGS ATTACHED

1 215 864

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(54) ELECTRO-FORMING OF CONTINUOUS SHEETS

(71) We, BUCKBEE-MEARS COMPANY, a Corporation organised and existing under the laws of the State of Minnesota, United States of America, of 245, E Sixth Street, St. Paul, Minnesota, United States of America,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention is directed generally to the field of electroplating or electroforming processes and equipments. More specifically it is directed toward the construction of an endless belt cathode for use in electroplating patterned strips of metal on both sides of the belt as it passes through an electrolytic bath.

The prior art in this field is probably best illustrated by United States Patent Specification No. 1,425,184. Although since the time of the said patent, materials and systems have been refined and have become somewhat more sophisticated, it probably best describes the basic operation of the type of continuous line electroforming system with which the present invention is concerned. However, the system described in the above patent, and other representing improvements and variations in the art, are directed toward producing a continuous imperforate foil or, in some instances, a foil that might contain perforation but of a random and limited nature. However, heretofore, it has not been possible to use continuous line electroforming systems of this nature to produce patterned foil or what might more appropriately be described as mesh. Mesh is a strip of metal having a multitude of patterned openings interspersed among metallized areas and resembles a fine screen. It is an object of this invention to provide apparatus for continuous electroforming process for producing strips of mesh on both sides of a cathode in the form of an endless belt.

Accordingly the invention provides apparatus for making sheets of perforated foil by electroplating, comprising: an endless belt made out of a metallic strip which is usable as a matrix cathode in an electroplating bath, said belt containing a multitude of holes passing completely therethrough, said holes being formed with other than straight-sided walls and containing a dielectric material characterised by being non-reactive with the electroplating bath, the said dielectric material covering completely at least the metal surrounding the edges of the holes and being locked thereto in a permanent fashion; means for continuously feeding said belt through the electroplating bath to receive deposits of metal layers on both sides; and means for stripping off the deposited metal layers after the belt leaves the bath.

The belt is constructed from a strip of metal, preferably stainless steel, which is initially treated, for example by industrial photoprinting processes and chemical milling, to produce a multitude of apertures passing completely through the belt in a pre-arranged precise pattern. At least the metal surrounding the edges of these holes is then covered with a dielectric material in such a manner that the dielectric material adheres thereto with great strength and is immovably locked in its location so as to be virtually indestructible. In this fashion both sides of the belt present to the anodes a cathode of interspersed dielectric and metallized areas as the belt passes through the electrolytic bath while the metal is deposited to the desired pattern. When the latter is stripped off both sides of the belt, the dielectric material remains firmly entrenched and the belt can be used over and over again.

In the drawings:—

Fig. 1 illustrates in schematic form apparatus for electroplating on both sides of a continuous belt which is continuously moving through the electroplating bath and which is constructed according to the invention;

Fig. 2 illustrates a typical hole pattern in the belt; and

Fig. 3 is a view along section line 3—3 showing in some detail the profile of the holes formed in the belt.

[Price 5s. 0d. (25p)]

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An endless metallic belt 10 is fed by driving rollers 11 into a tank 12 containing a suitable electroplating bath and suitably located and electrically connected anode racks 13. A pair of electrical contact rollers 14 pinch belt 10 between them to provide the correct electrical polarity to the metallic belt 10 so that it will function as the cathode in the electrolytic action within the tank 12. An adequate description of the invention does not require a detailed description of the electroplating bath or the construction of the anodes since these are all matters of choice which can be left to the skilled artisan to select. The choice, of course, depends on many factors including the metals involved and the desired plated thickness, among other things. The velocity at which the belt is driven through the electroplating tank 12 is also determinable for any given electrolytic plating process. Idler rollers 15, one at the input and one at the output ends of the bath, help to direct the line of travel of the belt 10. It is, of course, apparent that these rollers, and any other directional guides within the tank 12 and the tank itself, must be non-reactive in the electrolytic bath. These are usually made out of some suitable dielectric material.

In the usual fashion, after the belt 10 leaves the electroplating bath it passes through a cleaning chamber 16 which may be a bath of cleaning fluid or a spray tank or anything which will do an effective job of cleaning the electrolyte off the electroplated belt. Again, suitable idler rollers are strategically located to direct the line of travel of the belt. The constituency of the cleaning fluid and the manner of cleaning are also not essential to an understanding of the present invention and are quite well known or determinable by those of ordinary skill in the art. After the electroplated belt has been cleaned, the sheets of electroplated material are stripped off from both sides of the belt 10 in a fashion as illustrated in Fig. 1. A pair of pinch rollers 20 hold the plated belt firmly and the electroplated sheet 21 is stripped from the upper side of the belt 10 and rolled on spool 23 and continuous sheet 22 is removed from the under side of belt 10 and rolled on spool 24. The manner in which the layers are stripped does not constitute a part of the present invention so will not be here described in any detail. However, this is not to say that this step is not of some concern in the process because care must be taken to ensure that the metal is stripped off cleanly and yet not too rapidly nor with too great force to tear the metal. This is particularly troublesome when producing quite thin layers of metal foil containing a multitude of holes since the electroplated sheets, of course, are then in a very weakened condition.

Ordinarily, however, once the leading edge of the electroplated metal strip is lifted off and the roll-up started, maintaining the same continuous tension between the wind-up rollers or spools 23 and 24 and the pinch rollers 20, will permit the stripping to continue automatically without interruption. After the electroplated sheets 21 and 22 have been stripped off, the belt 10 is again fed into the electroplating tank 12 although in some instances it may undergo additional further cleaning or other processing steps (not shown) to prepare the belt surface so that the electroplated sheets will strip off cleanly and smoothly.

It goes almost without saying, of course, that precautions must be taken so that the various rollers which feed and direct the travel belt 10 into and through the electroplating tank 12 and outside must be constructed in such a manner that they will not injure the metal belt before or after electroplating.

Turning now to Figs. 2 and 3, some of the detailed construction of the belt 10 may be seen. In a typical case, the belt contains an array of holes or apertures 25 arranged in uniform rows and columns. These holes appear throughout the width and breadth of the belt 10. When a belt of this nature is transported through an electrolytic bath in the manner illustrated in Fig. 1, the metal deposited in the areas between the various apertures 25 is stripped off in mesh or screen form which may have, for example, 200 to 300 lines per inch. The holes 25 are filled with a dielectric material, in a manner which will be described later in more detail, to prevent metal from being deposited in the hole areas.

Preferably, the belt is made of stainless steel such as 301 or 316 stainless and it has been found that a thickness of 0.006 to 0.008 inch is preferable. In this range, the stainless steel is flexible enough to follow the circuitous route of the belt travel amongst the various guide rollers and yet is strong and durable enough to withstand the various bends and turns without rupturing. Other reasons for stainless steel being preferable are that it is less expensive than most of the other materials, it is relatively easy to weld to make into a closed loop belt, it is relatively easy to etch chemically for forming the holes, and its surface can be polished to a relatively high gloss so that even though the plated metal adheres quite well it can still be readily stripped off. Other materials which have been tried and found to be usable but do not quite have the same degree of desirable characteristics as stainless steel include nickel, cold-rolled steel and molybdenum steel. The latter is almost as good as stainless steel especially where quite thin layers of metal are electroplated because the metal appears to strip away from molybdenum steel even easier than from the stainless steel. However, this same feature is often a drawback to molybdenum steel. As the electroplated material builds up to an appreciable thickness it might strip away from the molybdenum steel belt by its own weight, even, perhaps, in the electroplating bath which can be very detrimental.

The belt is prepared by initially taking a long flat strip of metal such as stainless steel and subjecting it to industrial photoengraving process steps to produce the desired hole pattern. This is done by first coating both sides of the strip with a light sensitive enamel. There are a number of enamels which are suitable for this purpose, any one of which is merely a matter of choice to one of ordinary skill in the photoengraving field. The desired pattern is then printed on both sides using known photoprinting techniques in which a master plate (negative or positive) is placed over and in contact with the enamel coating and actinic light is projected through the plate on to the enamel. The most significant part of this step is that the various pattern areas must be printed in register on the opposite sides of the metal strip. Various techniques have been developed and equipments produced which can be used to achieve the desired registration. For example, U.S. Patent 3,199,430 titled "Photoprinting Apparatus" describes an apparatus and its operation which can be used. Ordinarily, because the master plate is only of a limited width, the pattern is photoprinted over the entire length of the belt by the step and repeat process. This involves reprinting the pattern repeatedly on adjacent areas step-by-step with each print being accurately indexed to the adjacent print to ensure uniformity of the pattern throughout the length of the strip. Techniques for doing this are well known in the art and need not be explained in detail here.

After the photoprinting step has been completed the pattern is developed out. In those areas where the enamel is struck by light it hardens but it remains in the soft condition where not exposed to light. The latter are then washed away. There remains on the surface of the belt an enamel coating with uncoated areas defining the aperture locations. The metal strip then is fed through an etching chamber where a suitable etchant such as ferric chloride for stainless steel is sprayed or otherwise applied to the surfaces of the belt to chemically mill away the uncovered aperture areas. Those familiar with etching techniques will recognize that certain controls have to be established and certain techniques and procedures followed to ensure that the etched holes are of the correct sizes. It is important that the holes be etched through from both sides of the strip. Further, it is important that the holes not be etched clean but that they be etched through in such a manner that the side walls of the openings are tapered inward such as illustrated in Fig. 3. This is what is known in the trade as being under-etched and can be done by controlling the etching in the etching chamber. Even though under-etching produces an aperture through the strip which if of uncertain and inaccurate dimensions, as long as the dimensions at the surfaces of the strip are accurate, there is no concern because the dimension at the surface will determine the definition and the size of the electroplated area. One precaution which should be followed in selecting the size and material for the belt is that the hole pattern should not weaken the belt so that it might rupture in use. In other words, a large number of holes makes the aperture-to metal ratio high and may present a problem in the operation of the electroplating system. Ordinarily, the weakened condition of the belt would be compensated for by making it thicker. However, one cannot go too far in that direction lest the belt be not flexible enough to follow the various bends in its circuitous path in the system. Further, when making the holes by chemical milling, a thicker belt ordinarily loses some definition.

After the holes have been formed and the belt suitably cleaned of all remaining enamel and other foreign materials, the holes must be filled with a dielectric material which will be held firmly in place to be durable enough to withstand continuous repetitive use and should not crack or flake off. The dielectric material should preferably still have some flexing capability when it has set or hardened so that the belt is flexible enough to go through the various bends and curves in the system. The material should also be non-reactive with the electroplating bath because ordinarily in the electroplating system the belt goes through some type of alkaline bath for cleaning. Various epoxy resins have been found completely suitable as well as polytetrafluoroethylene, known as "TEFLON" (Registered Trade Mark), silicone rubbers and even some resists which are used in silk screening processes.

To fill the holes, the strip is laid down on a flat surface, such as a table top, and the dielectric material is then flowed onto the upper surface. A typical suitable epoxy resin is that which is made by Minnesota Mining and Manufacturing and identified as EC1386. This material requires no catalyst and ordinarily is heat cured at a temperature of approximately 350°F. Rubber squeegee blades are pushed back and forth over the top of the strip to wipe the material off the surface and push it into the openings. This is usually done to a short section of the strip and when the holes appear to be filled, this section of the strip is heat treated to allow the dielectric material to harden or set. This is repeated for the remaining sections of strip. The same sections may have to go through this process a number of times until all of the holes are positively filled. Of course, other techniques could be used for this function. For example, the strip could be first formed into a continuous belt by butt welding its ends together and then continuously passing it through a tank of dielectric material followed by pressure rollers, and doctoring blades to force the material into the holes and to scrape off the excess and, of course, heating for hardening. The material which fills the holes such as those illustrated in Fig. 3 is locked tightly within these openings so there is no danger than the dielectric material will fall out of the holes when the belt is in use in the electroplating system. Another way of filling the holes is by spraying the dielectric material onto the belt. For example, polytetrafluoroethylene, known as "TEFLON" (Registered Trade Mark) may be inserted into the holes in this fashion. It is interesting to note that the holes need not be completely filled provided their edges are covered with dielectric material. When the belt is used in the electroplating system there is no danger that anode metal will be deposited within a hole if the entire edge of the hole is covered with a suitable dielectric material.

After the strip has been processed to fill the holes with dielectric material in the manner described, of course, it becomes necessary to make sure that all dielectric material is removed from the metallized areas of the strip. This is done by using a suitable abrasive material which not only removes the excess insulating material from the metal surface but also lowers the dielectric material within the apertures flush to the metal surface. Furthermore, further rubbing with a fine abrasive material puts a polish on the surface of the strip which then makes it easier to strip off the electroplated metal. It is, of course, inadvisable to use a solvent because this would attack the dielectric material within the apertures also. The metal strip is now formed into an endless belt by butt-welding the ends together, if this has not been done earlier in the preparation.

It should be pointed out that in the electroplating system illustrated in Fig. 1, a further processing step can be introduced to laminate the stripped metal sheet onto a supporting layer, such as a sheet of insulating material. Experience has shown that when this is done it is preferable that the material used to fill the holes by polytetrafluoroethylene known as "TEFLON" (Registered Trade Mark) to eliminate any danger of the laminating material adhering with any strength to the fill material which might be the case with other fill materials.

WHAT WE CLAIM IS:—

1. Apparatus for making sheets of perforated foil by electroplating, comprising: an endless belt made out of a metallic strip which is usable as a matrix cathode in an electroplating bath, said belt containing a multitude of holes passing completely therethrough, said holes being formed with other than straight-sided walls and containing a dielectric material characterised by being non-reactive with the electroplating bath, the said dielectric material covering completely at least the metal surrounding the edges of the holes and being locked thereto in a permanent fashion; means for continuously feeding said belt through the electroplating bath to receive deposits of metal layers on both sides; and means for stripping off the deposited metal layers after the belt leaves the bath.

2. Apparatus as claimed in claim 1 wherein the dielectric material in the belt holes is flush with the surface of the metallic areas of the belt.

3. Apparatus as claimed in claim 1 or 2 wherein the dielectric material completely fills the holes in the belt.

4. Apparatus as claimed in claim 1, 2 or 3 wherein the filling is an epoxy resin.

5. Apparatus as claimed in claim 1, 2 or 3 wherein the filling is polytetrafluoroethylene.

6. Apparatus as claimed in claim 1, 2 or 3 wherein the filling is a silicone rubber.

7. Apparatus for making sheets of perforated foil by electroplating, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1215864 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

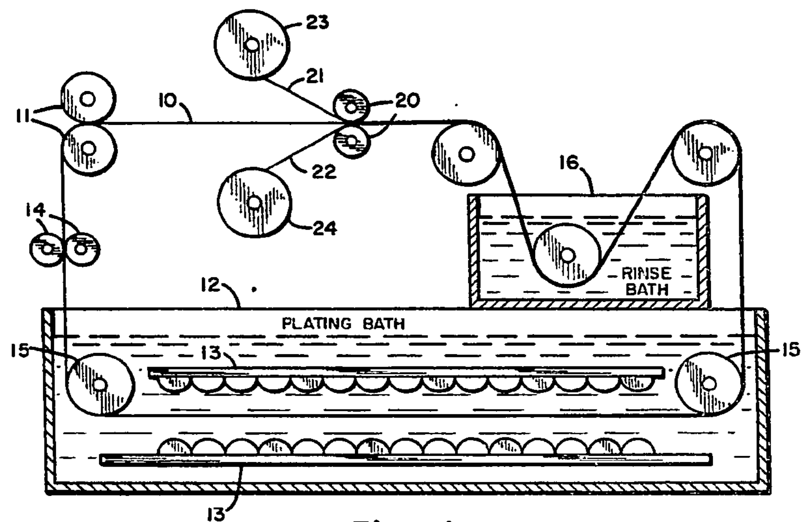

Fig. 1

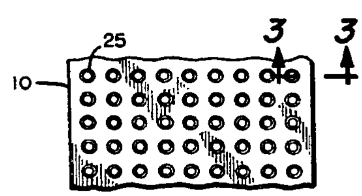

Fig. 2

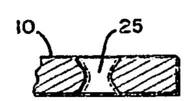

Fig. 3

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